base station to measure the mobile radio's reverse channel power and for the mobile radio to utilize the power control bit stream from the base station on the forward channel.

A multi-access channel, however, does not have a one-to-one channel pairing, as multiple mobile radios can transmit simultaneously. The identity of the mobile radio, therefore, is not necessarily known to the base station. Also, the mobile radios do not know the number of mobile radios transmitting, thus the association of the power control bit stream is not clear to the mobile radio.

Since the mobile radio aligns its transmit timing with the timing of the signals that it receives from the base station and all base station signals are time aligned, when two simultaneous transmissions occur on the reverse channel and there is no multipath, the transmissions arrive at the base station separated by times equal to the difference of twice the distances between each mobile radio and the base station. If this time exceeds one pseudo noise chip, the two transmissions can be distinguished by the base station. The inability to distinguish these multipath transmissions is a collision.

When there is multipath, there is no collision if the base station can identify and properly combine the multipath components. If three or more access channel transmissions occur in the same slot, then some transmissions may collide while others do not. In a typical multi-access channel, such as is found in a TDMA or an FDMA system, when two simultaneous transmissions occur there is a collision and neither transmission is successfully demodulated by the base station.

Base stations may further reduce interference with each other by transmitting with the minimum power necessary for their signals to be received by the base station. A mobile radio transmits its first transmission or probe at a power level somewhat less than it estimates to be necessary to reach the base station. This conservative estimate may be a predetermined value or it may be calculated in response to the measured power level of a signal that the mobile radio has or is receiving from the base station.

A preferred embodiment is for the mobile radio to measure the received power from the base station. This received power is the transmitted power of the base station times the path loss. The mobile radio then uses this estimate, plus a constant correction, plus adjustment factors to set the initial transmit power. These adjustment factors may be sent to the mobile radio from the base station. Some of these factors correspond to radiated power of the base station. Since the path loss from the mobile station to the base station is essentially the same as from the base station to the mobile station, the signal received at the base station should be at the correct level, assuming that the base station has supplied the appropriate correction factors and that the mobile radio and base station gains are error free.

After transmitting the first access probe at this minimum power level, the mobile station increases the power of successive probes within each access probe sequence by a predetermined step amount. A thorough discussion of access probes is evident in IS-95, section 6.6.3.1 and in co-pending U.S. patent application, *Apparatus and Method for Reducing Collisions Between Mobile Stations Simultaneously Accessing a Base Station in a CDMA Cellular Communications System,* Ser. No. 08/219,867 to Tiedemann et al. and assigned to Qualcomm, Inc.

In addition, between successive transmissions of an access probe, the mobile radio can randomize its transmission time and choose another access channel so as to avoid a potential collision. IS-95, section 6.6.3.1 describes this in greater detail.

It can be seen, therefore, that power control is very important for proper operation of a CDMA radiotelephone system. There is a resulting need for a power control process in a multiple access system to increase system capacity.

SUMMARY OF THE INVENTION

The power control process of the present invention uses a comparison threshold to determine whether the base station should instruct the mobile radios to increase or decrease their transmit power. The total received $^{Eb}/_{Io}$ for all the mobile radios communicating with a particular base station is compared to a maximum threshold for the reverse channel. Additionally, a minimum comparison threshold for the mobile radio being controlled is determined. If the total received $^{Eb}/_{Io}$ is greater than or equal to the maximum threshold or the minimum received $^{Eb}/_{Io}$ for any mobile radio is greater than the reverse channel minimum, the base station instructs the mobile radios to decrease their output power. If the total received $^{Eb}/_{Io}$ is less than the maximum reverse channel threshold and the minimum received $^{Eb}/_{Io}$ for any mobile radio is less than or equal to the reverse channel minimum, the base station instructs the mobile radios to increase power.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a flowchart of the process of the present invention.

FIG. **2** shows a graph of the frame error rate versus $^{Eb}/_{Io}$.

FIGS. **3***a* and **3***b* show a typical forward packet channel structure in accordance with the present invention.

FIG. **4** shows the power control bit positions in accordance with the present invention.

FIG. **5** shows a block diagram of a typical mobile radio in accordance with the present invention.

FIG. **6** shows a block diagram of a typical base station in accordance with the present invention.

FIG. **7** shows the format of a forward CDMA channel in accordance with the present invention.

FIG. **8** shows the format of a reverse CDMA channel in accordance with the present invention.

FIG. **9** shows a plot of the transmit power of two radios and their reaction to power control commands in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention encompasses a pair of channels, subsequently referred to as the forward and reverse packet channels. The base station communicates with the mobile radios over the forward channel and the mobile radios communicate with the base station over the reverse channel. A base station uses the power control process of the present invention, over the forward packet channel, to dynamically adjust the transmit power of one or more mobile radios transmitting on the reverse packet channel.

The following discussion refers to mobile radios and base stations as the preferred embodiment. Mobile radios include radiotelephones used in both a terrestrially based communication system and a satellite based communication system. Similarly, the base stations can be located on the earth or as orbiting satellites.